

Combination Service for Time-variable Gravity Fields (COST-G) – GRACE-FO operational combination

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GSTM 2020

A.2 - Analysis Techniques & Inter-comparisons



Contents

- Introduction to COST-G
- Components of COST-G
- COST-G operational GRACE-FO combination:
 - Quality control
 - Combination
 - Validation
- Conclusions and Outlook

Introduction

Gravity and geoid metadata

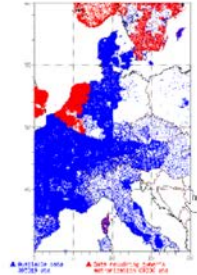
Online applications for the creation of metadata for gravity and geoid data. Service for searching the metadata database.

g-meta
the gravity metadata editor
(v0.2.6 - beta edition)

N-meta
the geoid metadata editor
(v0.1.3 - alpha edition)

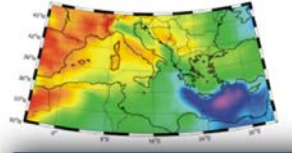
Gravity data

Land, marine, airborne gravity data as point and gridded values. Absolute and relative gravity data, WGM



Geoid

Geoid models and geoid determination software, geoid modeling processing methodologies



IGFS Mailing Lists

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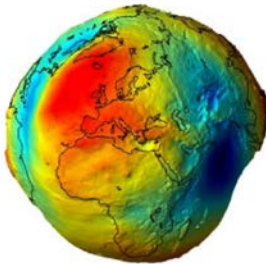
SG and Earth tide data

Temporal variations of the Earth gravity field through long-term records from ground gravimeters, SG data, Earth tide data.



Global Earth Models

Collection and archive of all existing global gravity field models, web interface for access to GEMs, model visualization and service.



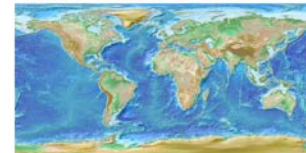
Time-variable GEMs

Combined gravity field solutions in SH coefficients and spatial grids for hydrological, oceanic and polar ice sheets applications.



DEM data

Digital Elevation Models, relevant software for DEM creation, assessment, manipulation and display, global relief and crustal models and spherical harmonic data sets.



COST-G is a product center of the



<http://igfs.topo.auth.gr/>



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COST-G Website



Welcome to COST-G

The International Combination Service for Time-variable Gravity Fields (**COST-G**) is a product center of the International Gravity Field Service (IGFS) and is dedicated to the combination of monthly global gravity field models. COST-G stems from the activities of the former H2020 project European Gravity Service for Improved Emergency Management (EGSIEM).

Please use the top menu to visit the various parts of our website!

The service started its work in 2019 and the website is still under construction. More features will be available soon! We apologize for any inconvenience. For any questions, please contact us.

Best regards,
Your COST-G Team.

<https://cost-g.org/>

Latest News

June 16th 2020

COST-G RL01 Level 2B and Level-3 products are available and the GravIS portal has been updated!

May 19th 2020

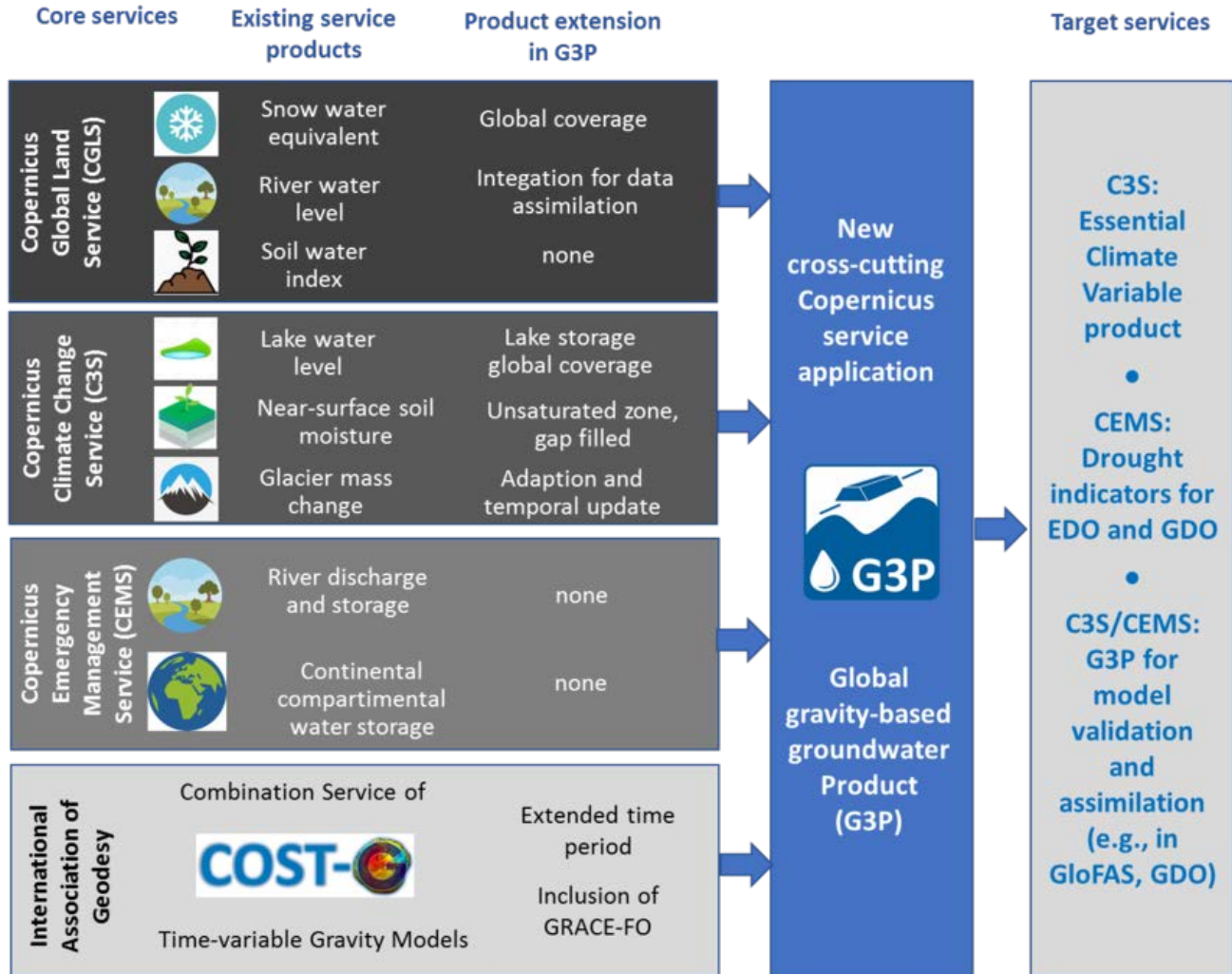
New article published in the International Association of Geodesy Symposia.



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COST-G and the H2020 G3P-project



COST-G is further developed within the frame of the Horizon 2020 project: G3P -Global Gravity - based Groundwater Product

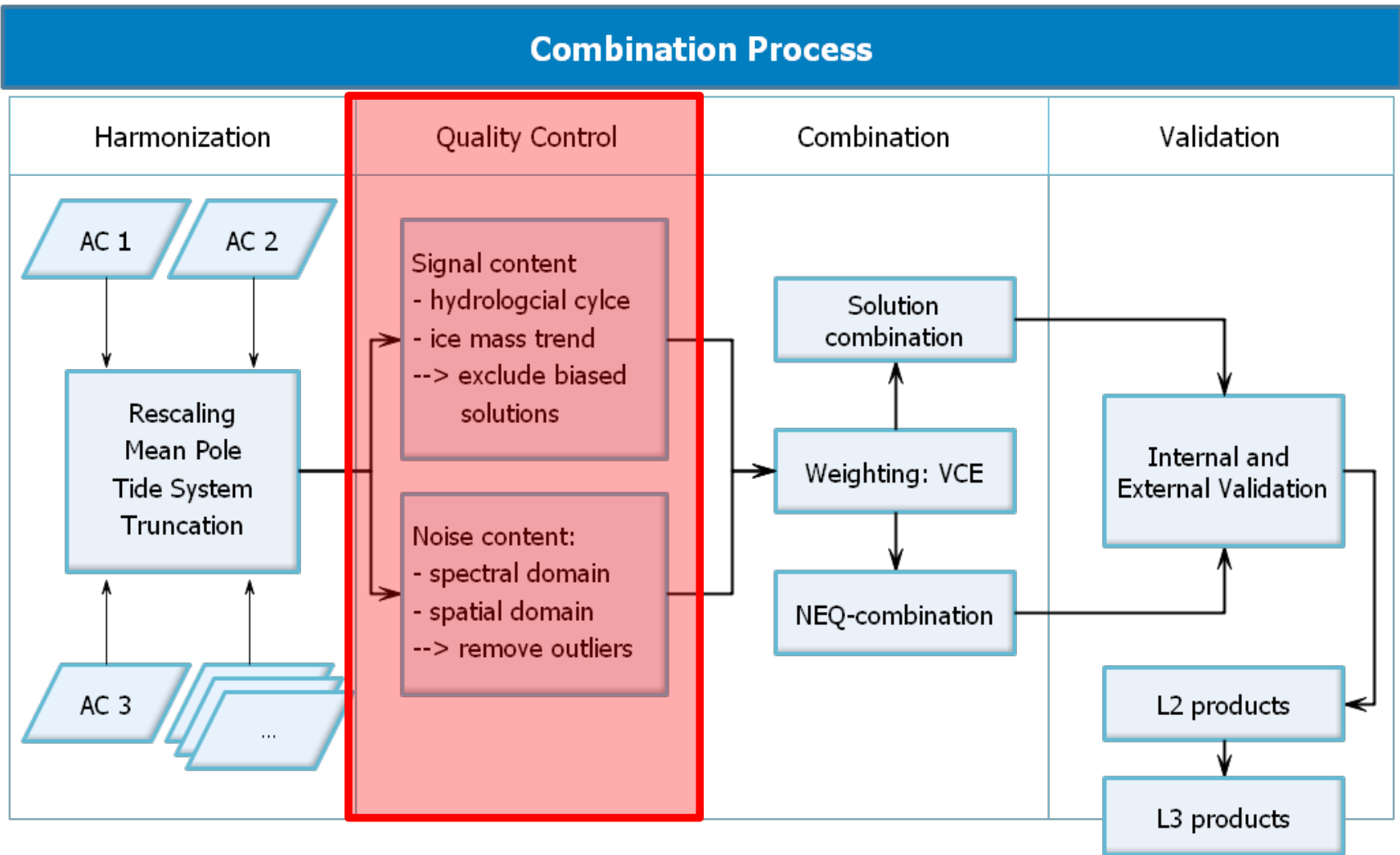
Permanent Components of COST-G

COST-G accomplishes its objectives through the following permanent components and roles:

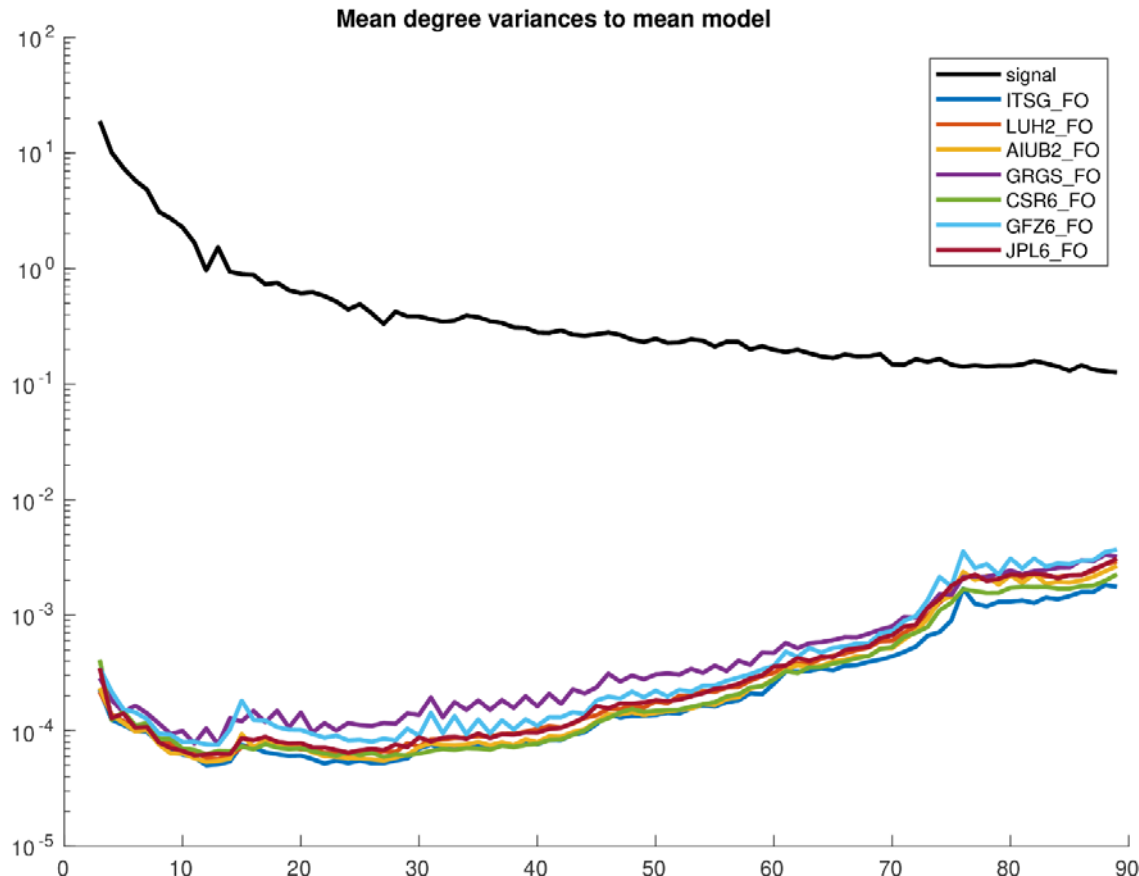
- **Central Bureau (CB) & Analysis Center Coordinator (ACC)**
 - AIUB
- **Analysis Centers (ACs)**
 - AIUB, CNES, GFZ, TUG
- **Candidate ACs: LUH, Chinese ACs**
- **Level-3 Center (L3C)**
 - GFZ
- **Validation Centers (VCs)**
 - GRGS, GFZ
- **Product Evaluation Group (PEG)**
 - A. Eicker, A. Groh, B. Meyssignac

GRACE/GRACE-FO
SDS (CSR, JPL)
contribute as
partner ACs to COST-
G combinations.

COST-G Quality Control



Quality Control – Noise Levels (spectral domain)



GRACE-FO time-series:

COST-G ACs:

- AIUB-GRACE-FO_op
- GFZ-RL06 (GFO)
- GRGS-RL05: free solution
- ITSG-Grace_op

COST-G candidate AC:

- LUH

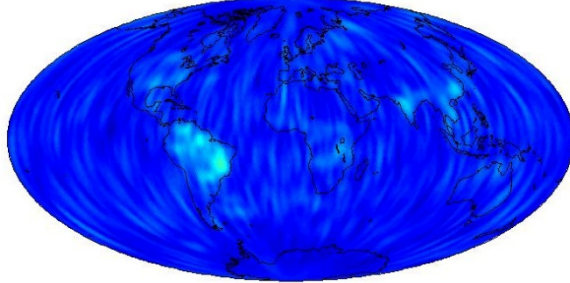
COST-G partner ACs:

- CSR-RL06 (GFO)
- JPL-RL06 (GFO)

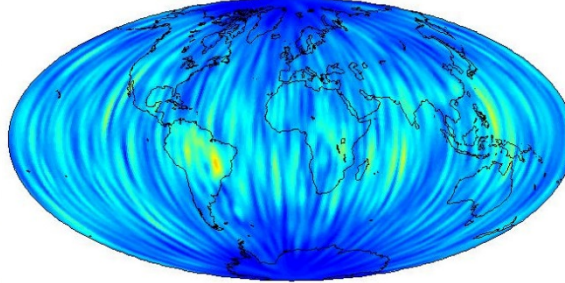
Degree-wise comparison of spherical harmonic coefficients to a deterministic signal model derived from the monthly means of all time-series (GRACE-FO).

Quality Control – Noise Levels (spatial domain)

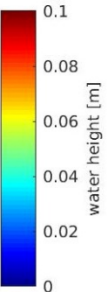
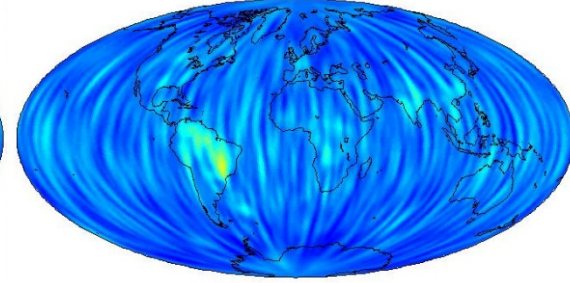
RMS of anomalies of ITSG_FO, expressed in EWH



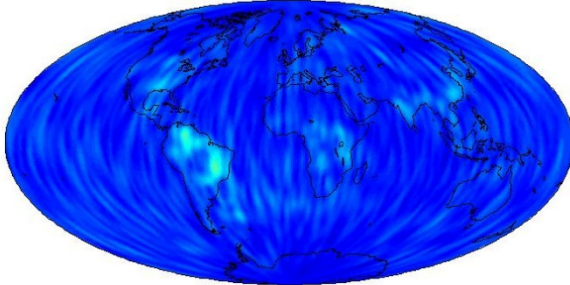
RMS of anomalies of GRGS_FO, expressed in EWH



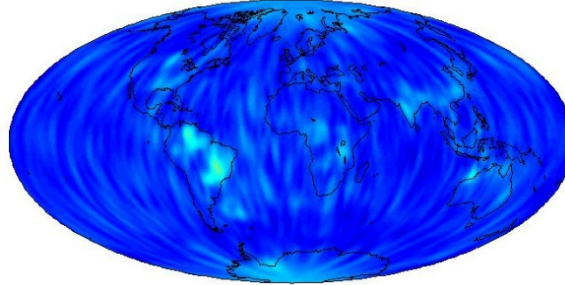
RMS of anomalies of GFZ6_FO, expressed in EWH



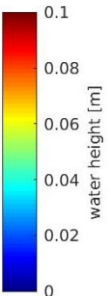
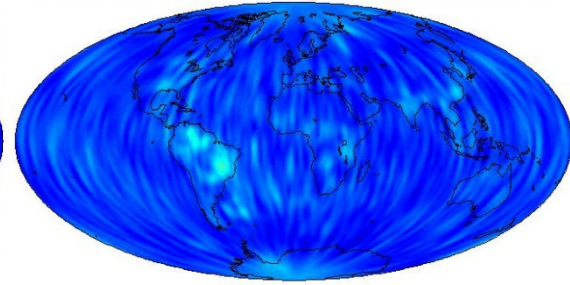
RMS of anomalies of LUH2_FO, expressed in EWH



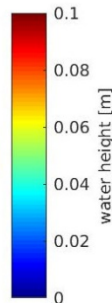
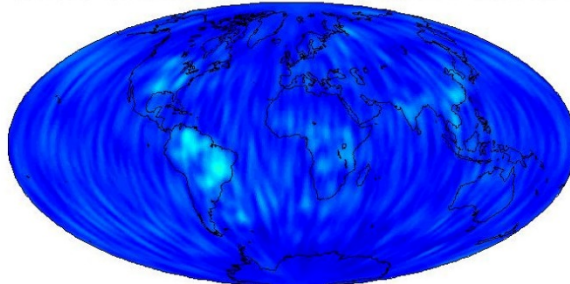
RMS of anomalies of CSR6_FO, expressed in EWH



RMS of anomalies of JPL6_FO, expressed in EWH

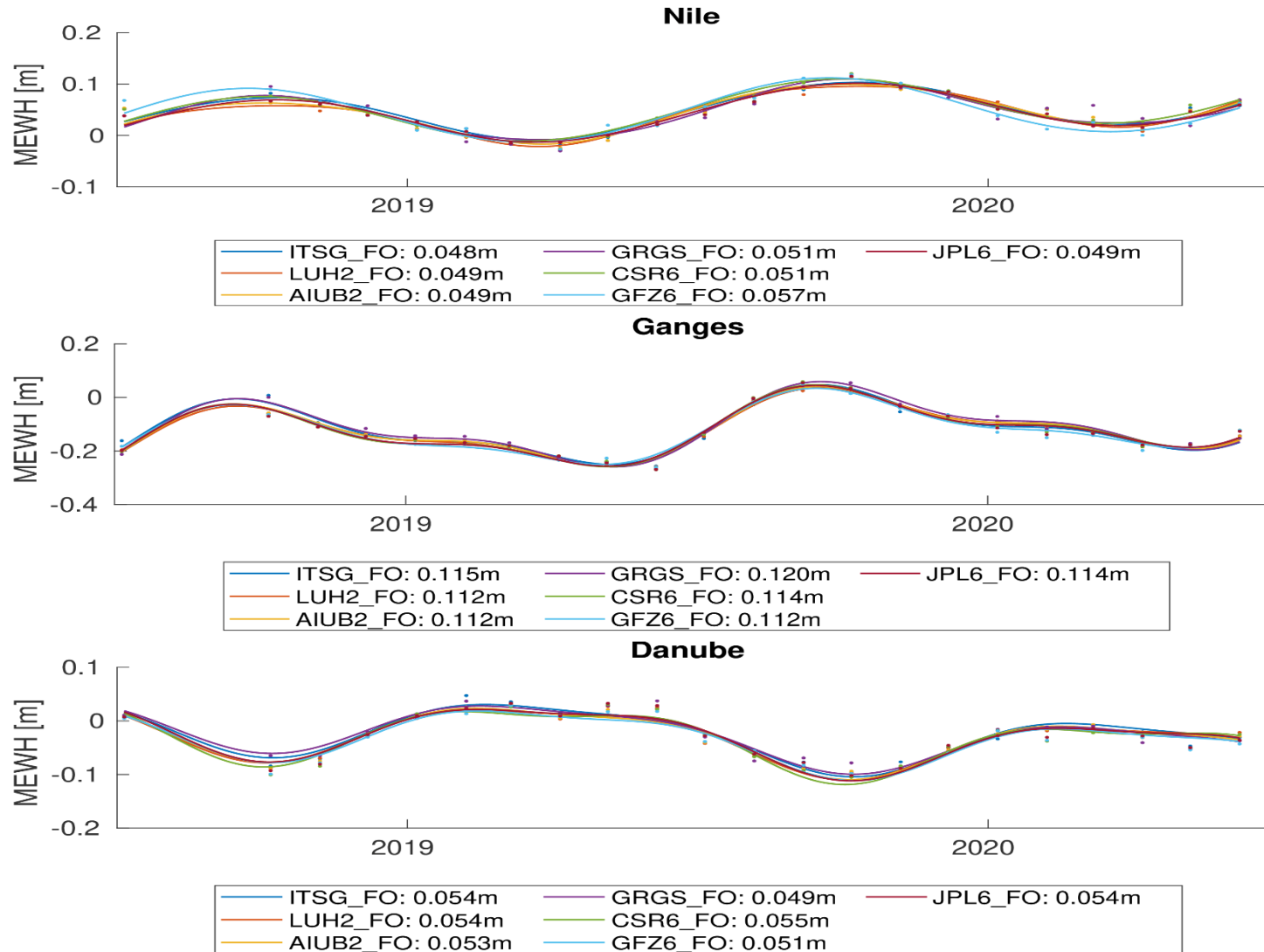


RMS of anomalies of AIUB2_FO, expressed in EWH



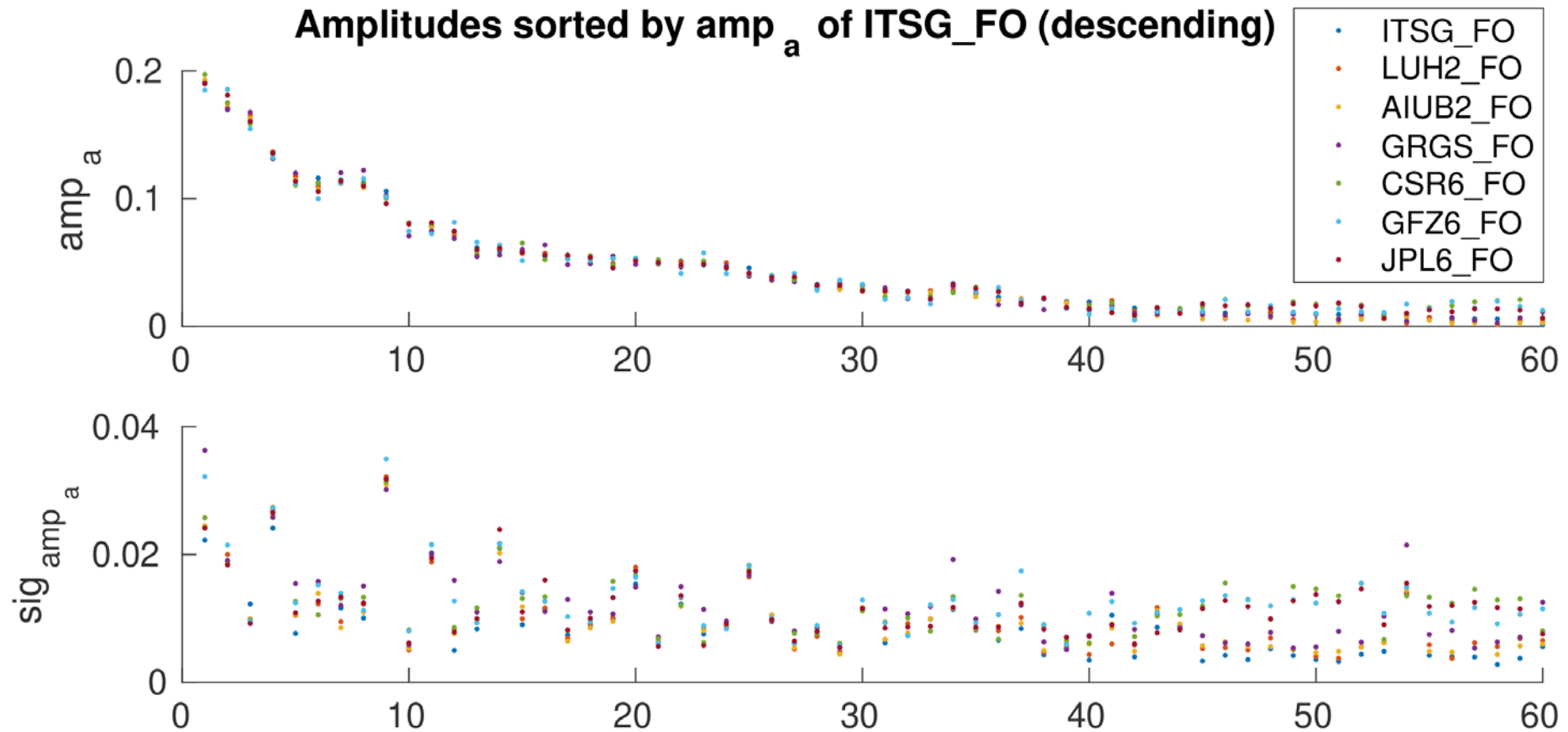
Comparison of monthly grids to a deterministic signal model derived from the monthly means of all time-series (GRACE-FO). Shown are the RMS-values per grid cell over a common subset of monthly solutions per time-series.

Quality Control – Signal Content (Hydrology)



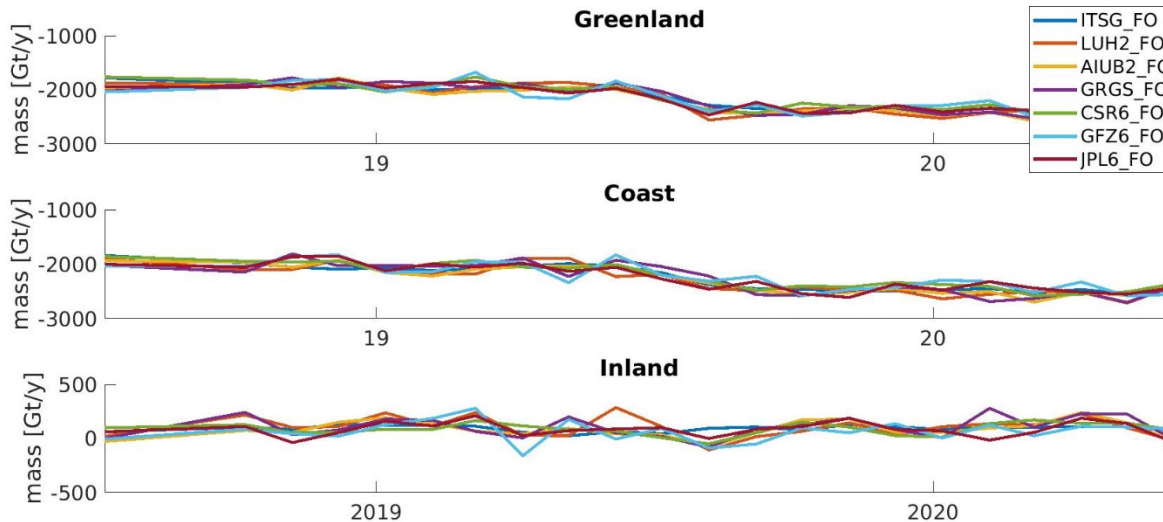
Example: fit of seasonal variations in selected river basins (GFO).

Quality Control – Signal Content (Hydrology)

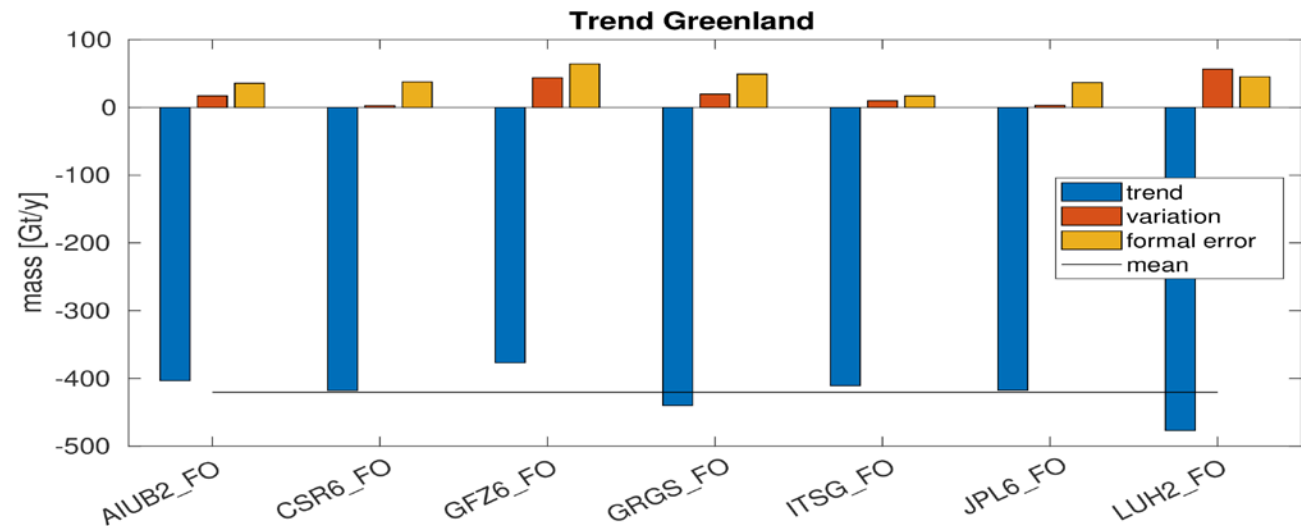


Comparison of amplitudes amp_a of seasonal mass variations and their formal errors sig_{amp} in 60 major river basins.

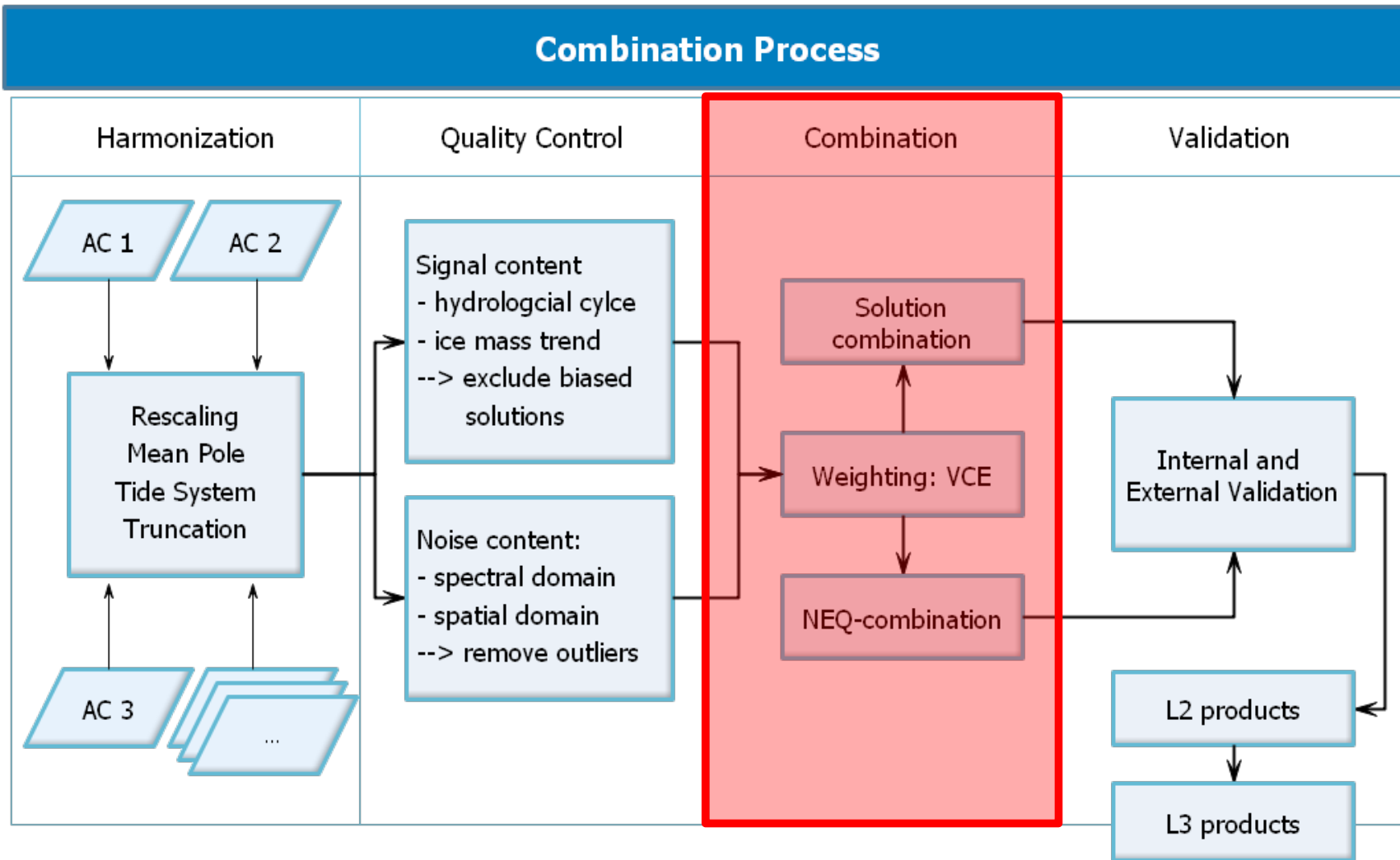
Quality Control – Signal Content (Ice Mass Loss)



Example: ice mass loss in Greenland (GFO) with respect to GOCO05S.

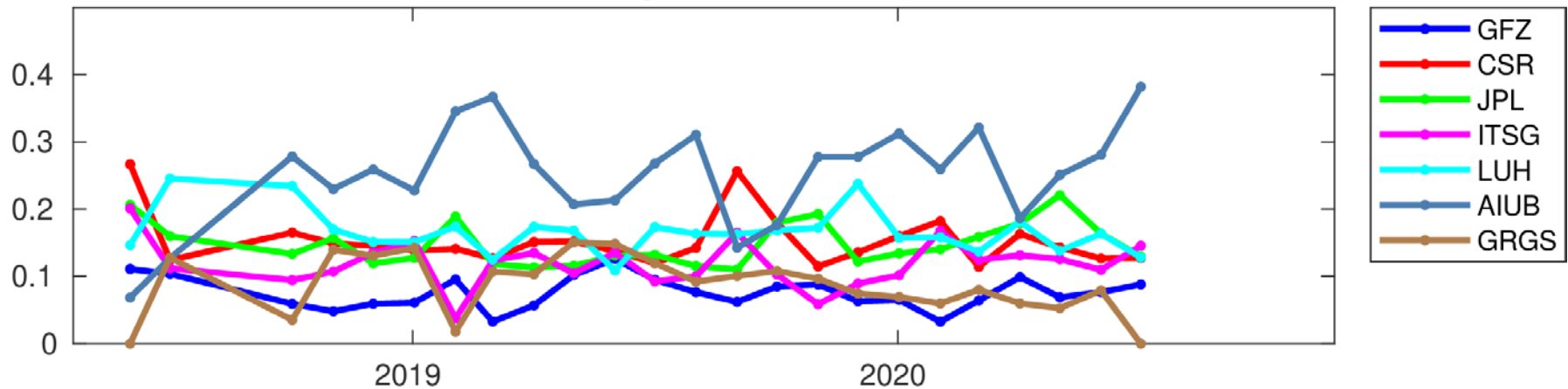


COST-G – Combination

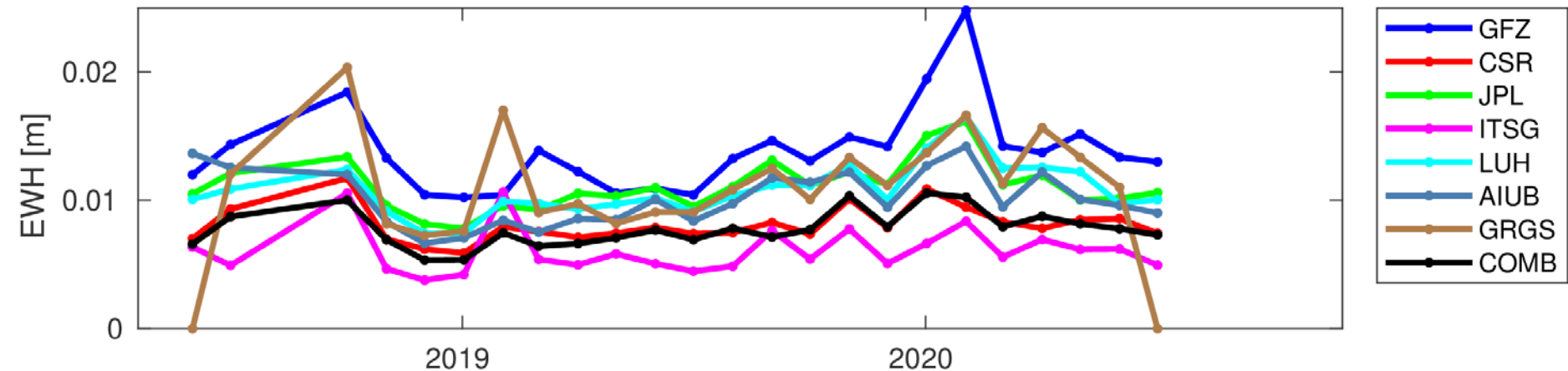


Combination applying Variance Component Estimation

VCE-derived weights (normalized):

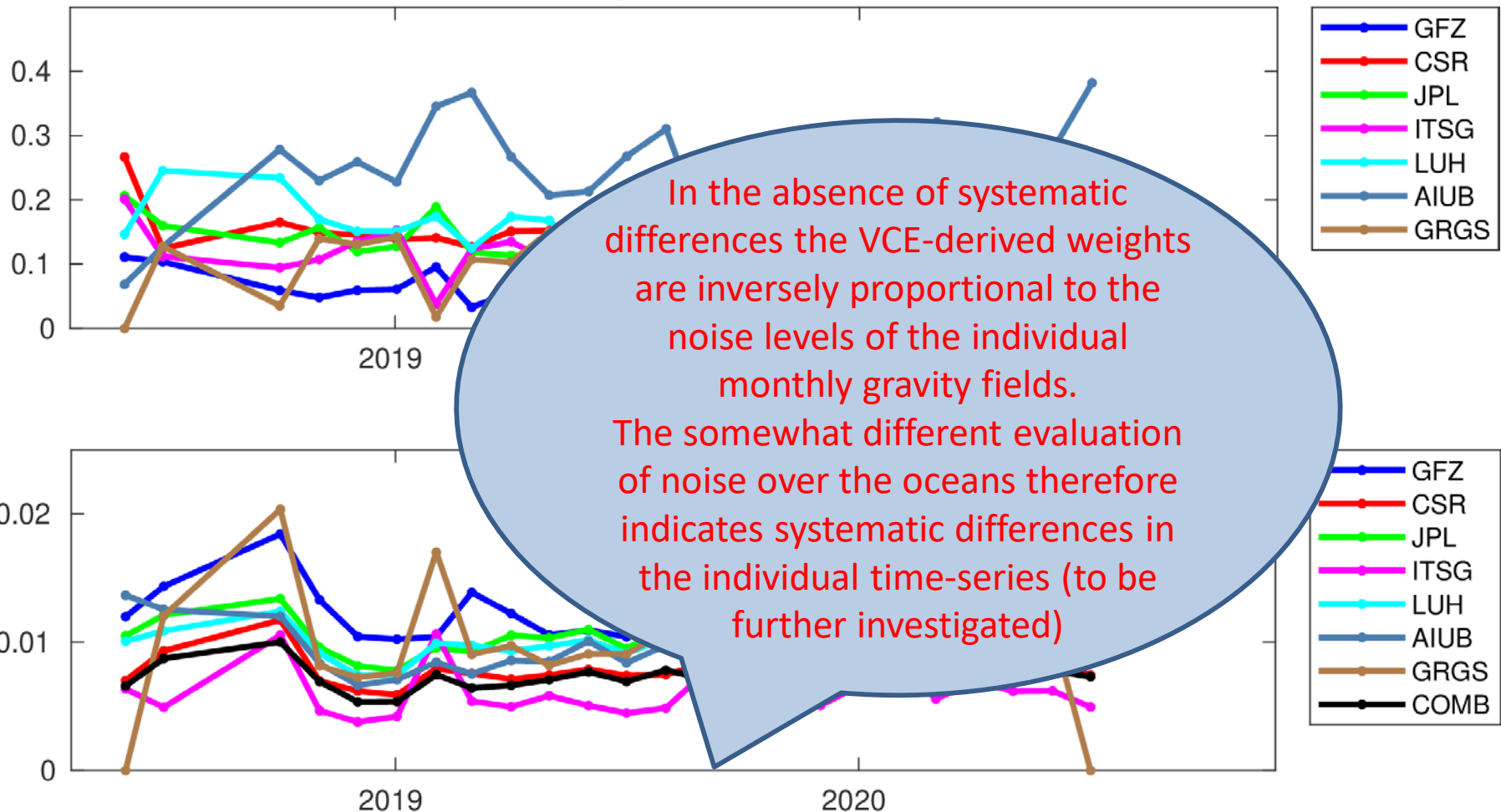


Noise over the oceans:

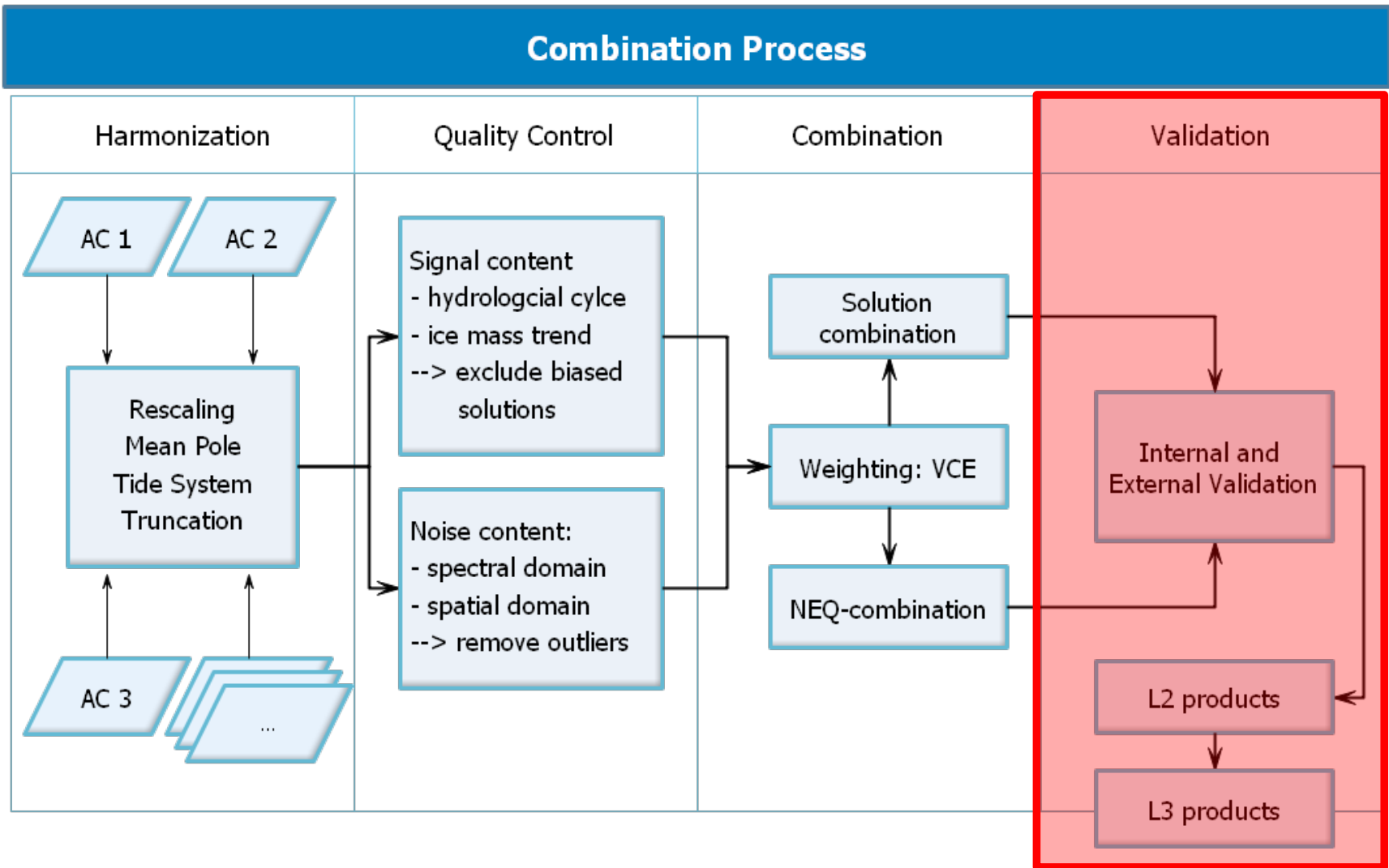


Combination applying Variance Component Estimation

VCE-derived weights (normalized):



COST-G – Validation

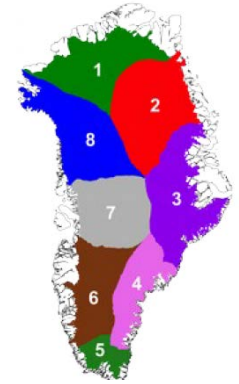
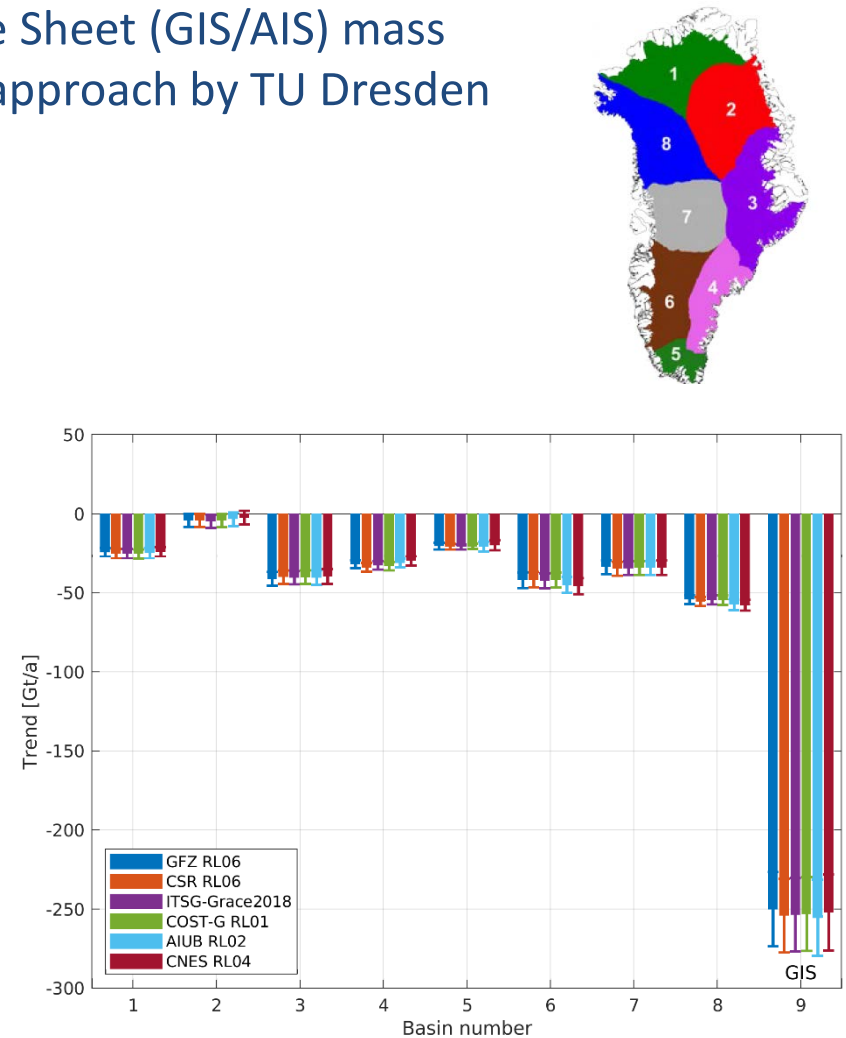


Basin-Averaged Greenland Ice Mass Changes

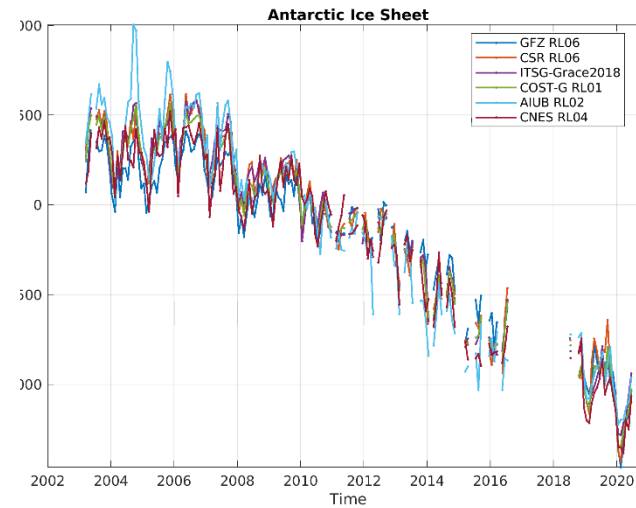
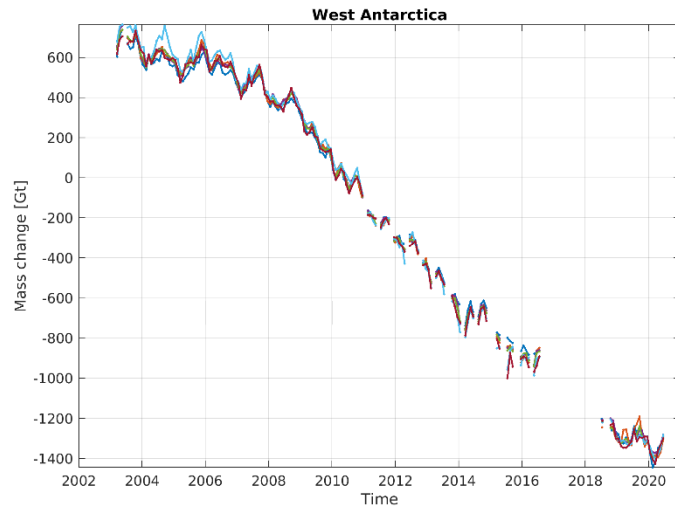
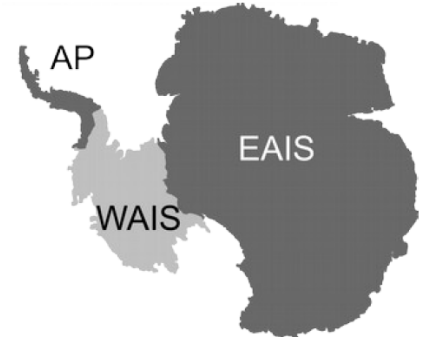
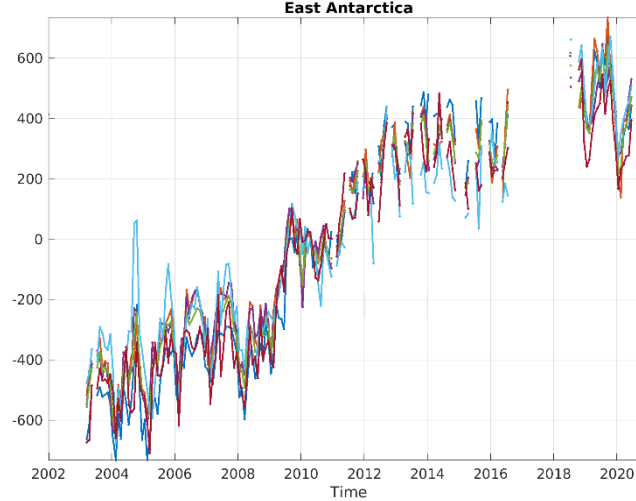
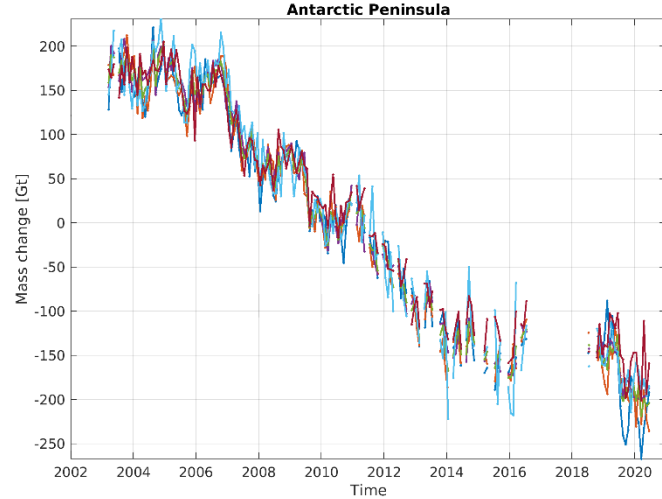
Basin-integrated Greenland/Antarctic Ice Sheet (GIS/AIS) mass changes based on the sensitivity kernel approach by TU Dresden



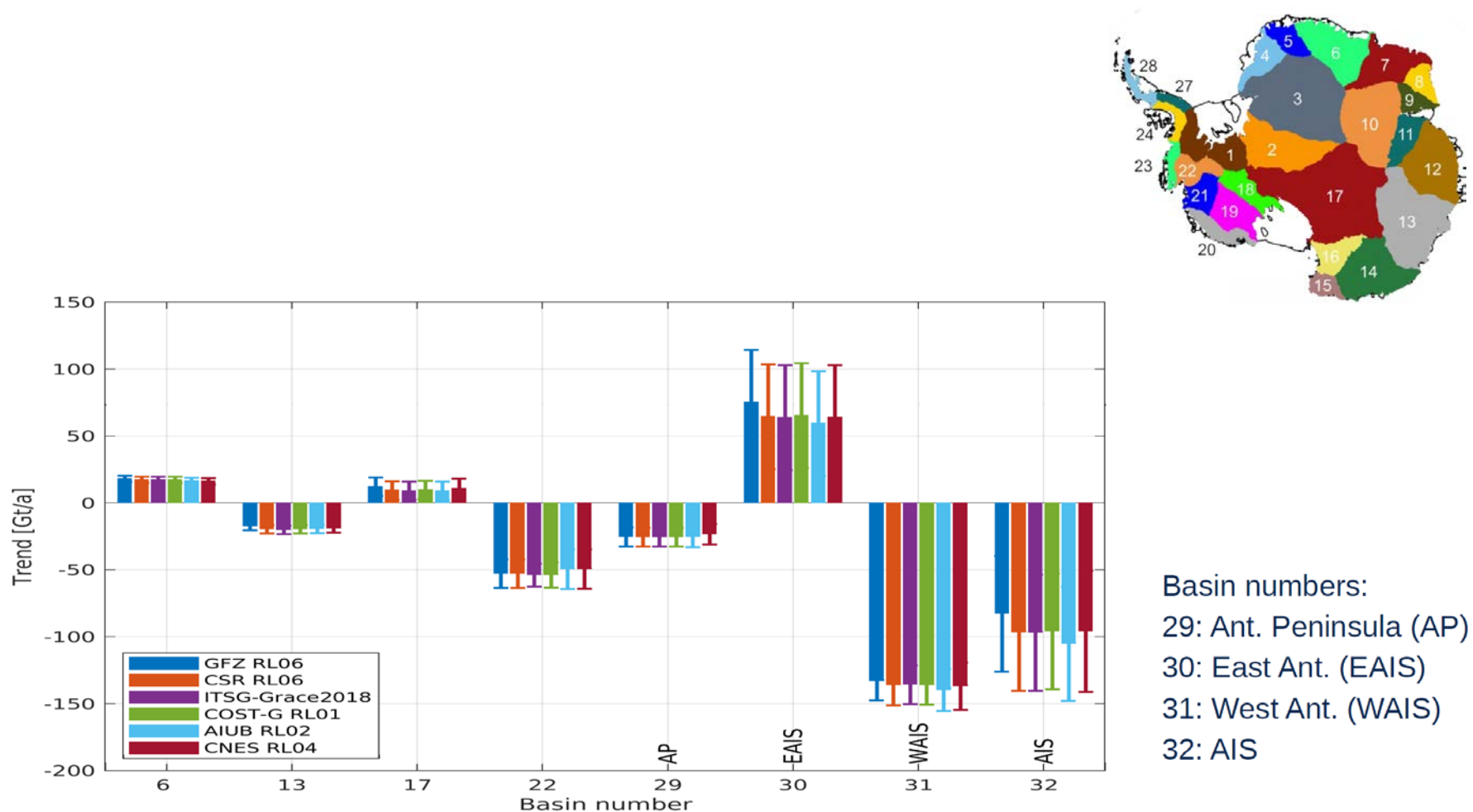
Trends are calculated from GRACE and GRACE-FO results.



Basin-Averaged Antarctic Ice Mass Changes



Basin-Averaged Antarctic Ice Mass Changes

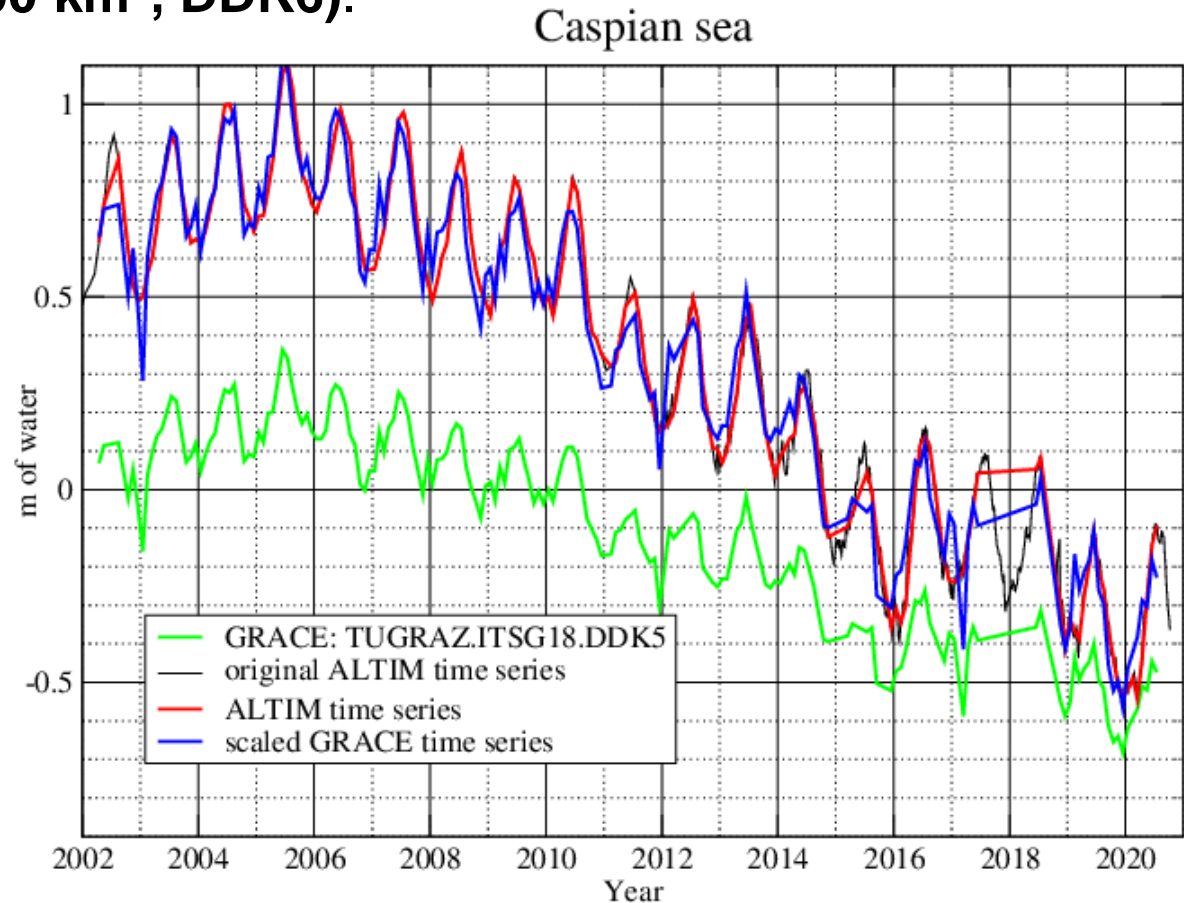


Comparison to Altimetry

SIGNAL ASSESSMENT:

- Caspian sea (386.400 km², DDK5),
- Black sea (181.000 km², DDK6).

Method: Filtered time series of the TVG solutions are compared with the time series of altimetric heights (from Hydroweb for the Caspian Sea or AVISO+ for the Black Sea). One scale factor and one bias (irrelevant) are adjusted.



Comparison to Altimetry

QUALITY CRITERIA:

- Correlation: aim for 100%
- Scale factor: aim for 1

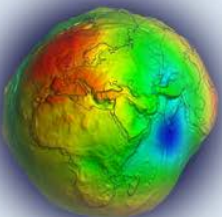
	Correlation (Black Sea)	Scale factor (Black Sea)	Correlation (Caspian S.)	Scale factor (Caspian S.)
CSR-RL06	71.8 %	1.23	98.2 %	1.64
GFZ-RL06	71.5 %	1.25	97.8 %	1.66
JPL-RL06	69.2 %	1.27	97.6 %	1.61
ITSG	72.3 %	1.21	98.3 %	1.62
COST-G	79.6 %	1.07	98.3 %	1.63

Orbit Tests with GOCE

- GRACE solutions up to d/o 60 and 90 filled up with DIR-6 up to d/o 240:
 - Table shows RMS of orbit fits (cm) for the different test cases (3D-residuals, mean values from 60 individual arcs)

Gravity model	Month					
	2019/11		2019/06		2018/11	
	90	60	90	60	90	60
GFZ_RL06	8.93	7.08	8.08	6.73	9.00	7.11
JPL_RL06	9.22	7.06	8.33	6.86	8.17	6.86
CSR_RL06	9.01	6.86	7.84	6.62	7.97	6.88
GRGS (unconstr. Sol.)	9.01	6.77	7.74	6.59	7.52	6.50
LUH	9.78	7.19	9.27	6.92	7.78	6.56
AIUB operational	9.42	7.33	7.97	6.95	7.53	6.81
ITSG operational	9.27	6.86	6.92	6.47	6.70	6.32
COST-G	8.58	6.97	7.36	6.57	7.34	6.60

Level-2 Product Availability



ICGEM Home

Gravity Field Models

- Static Models
- Temporal Models
- Topographic Gravity Field Models

Calculation Service

- Regular grids
- User-defined points

3D Visualisation




- Static Models
- Temporal Models
- Trend & Amplitude
- Spherical Harmonics

Evaluation

- Spectral domain
- GNSS Leveling

Documentation

- FAQ



Gravity Field Solutions for dedicated Time Periods

The following gravity field time series are presently available:




GRACE and Grace-FO solutions from the Science Data System centers CSR, GFZ and JPL				collapse all
- CSR	Center for Space Research at University of Texas, Austin			
- GFZ	Helmholtz Centre Potsdam German Research Centre for Geosciences			
GFZ Release 05	monthly	weekly	GFZ GRACE Level-2 Processing, Revised Edition, January 2013	
GFZ Release 06	DOI	monthly	GFZ GRACE Level-2 Processing Standards Document for Level-2 Products, Rev. 1.0, October 26, 2018	
GFZ Release 06 (GFO)	DOI	monthly	GFZ GRACE Level-2 Processing Standards Document for Level-2 Products, Rev. 1.0, June 3, 2019	
- JPL	Jet Propulsion Laboratory			


The processing standards to generate the GRACE Level-2 products of CSR, GFZ and JPL are also available in the Document Section of the GRACE archives at [GFZ ISDC](#) or [JPL PO.DAAC](#)

COST-G (International Combination Service for Time-variable Gravity Field)				collapse all
GRACE	DOI	monthly		
Swarm	DOI	monthly		

GRACE / CHAMP solutions from other groups				expand all
+ AIUB	Astronomical Institute University Bern			
AIUB-GRACE-FO_op	DOI	monthly	Operational GRACE Follow-On monthly gravity field solutions from AIUB	
AIUB-RL02		monthly	GRACE monthly solutions Release 2 from AIUB, more information can be found here	
+ CNES	Centre national d'études spatiales			

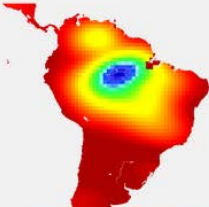
Level-3 Product Availability



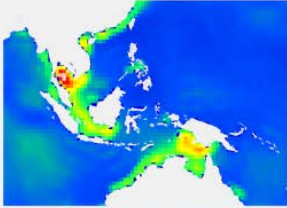
[TERRESTRIAL WATER STORAGE](#)[OCEAN BOTTOM PRESSURE](#)[ANTARCTIC ICE-MASS CHANGE](#)[GREENLAND ICE-MASS CHANGE](#)[CORRECTIONS AND AUXILIARY PRODUCTS](#)[RELATED LINKS](#)

Welcome to GravIS, the Gravity Information Service of the German Research Centre for Geosciences (GFZ), in collaboration with the Alfred-Wegener-Institut (AWI) and Technische Universität Dresden. Data products derived from the gravimetric Earth observation satellite missions GRACE and GRACE-FO are widely used by scientists and other interested users to study mass variations in the Earth system. However, processing of GRACE/GRACE-FO data into user-friendly products for dedicated geophysical applications is nontrivial, neither when starting from original satellite observations nor from the level of gravity field products. In order to enable the usage of satellite gravimetry data for a broader community, user-friendly ('Level-3') products are generated by various institutions.

GravIS visualizes and describes Level-3 products based on the most recent [GRACE and GRACE-FO data](#) release from GFZ. In addition, Level-3 products based on the most recent release of [combined GRACE models from COST-G](#) are offered as well. The products presented at GravIS are available for download at [GFZ's Information System and Data Center \(ISDC\)](#).



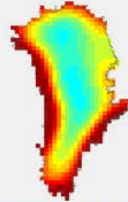
Terrestrial Water Storage



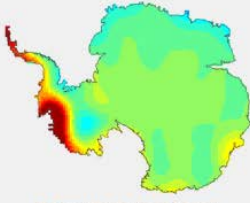
Ocean Bottom Pressure

The Gravity Recovery and Climate Experiment (GRACE; 2002 - 2017) and its Follow-On mission (GRACE-FO; launched in May 2018) typically provide monthly independent estimates of the Earth's global gravity field. Differences between consecutive months are caused by mass redistribution and mass transport in the Earth system, particularly in the geophysical fluid layers of the atmosphere, oceans, and continental hydrosphere.

GRACE/GRACE-FO data processing is structured into [sensor data analysis \(Level-0 to Level-1\)](#), [global gravity field estimation \(Level-1 to Level-2\)](#), and [geophysical mass anomaly inversion \(Level-2 to Level-3\)](#). Level-3 products at GravIS comprise gridded mass anomalies as well as basin average time series and are available for [terrestrial water storage over non-glaciated regions](#), [bottom pressure variations in the oceans](#), and [ice-mass changes in both Antarctica and Greenland](#). In order to achieve the highest possible accuracy of the mass anomalies, several post-processing steps have been applied to the Level-2 spherical harmonic coefficients before inversion.



Greenland Ice-Mass Change



Antarctic Ice-Mass Change

Summary and Outlook

- **COST-G combined Level-2 products for GRACE (repro) and Swarm (operational) are available from ICGEM, operational GRACE-FO combinations are in the process of publication (matter of days).**
- **COST-G Level-3 products for GRACE are available via GFZ's GravIS portal (<http://gravis.gfz-potsdam.de/>), GRACE-FO will follow within 2-3 weeks.**
- **Inclusion of further candidate Analysis Centers (Chinese ACs) is planned for 2021 (benchmark testing and quality control are being performed).**